A novel framework to capture dispersed anisotropy in electro-active polymers

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ABSTRACT

In the last couple of years, the so-called electro-active polymers (EAPs) have been gaining popularity within the smart materials community. The core mechanism of EAPs is an electro-mechanical coupling behaviour where an electric energy converts into a mechanical energy thanks to stimulation by an electric field. In contrast to traditional piezoelectric materials of small strain actuation mechanisms, the excitation on EAPs by an external electric field results in a large deformation. It also results in a change in their material behaviour, e.g. the polarization response. To enhance actuation behaviour, particle-filled EAPs become promising candidates nowadays. Recent studies suggest that particle-filled EAPs, which can be cured under an electric field during the manufacturing time, do not necessarily form perfect anisotropic composites, rather they create composites with dispersed chains. Hence in this contribution, an electro-mechanically coupled constitutive model is devised that considers the chain dispersion with a probability distribution function (PDF) in an integral form. To obtain relevant quantities in discrete form, numerical integration over the unit sphere is utilised. Necessary constitutive equations are derived exploiting the basic laws of thermodynamics that result in a thermodynamically consistent formulation. To demonstrate the performance of the proposed electro-mechanically coupled framework, we analytically solve a non-homogeneous boundary value problem, the extension and inflation of an axisymmetric cylindrical tube under electro-mechanically coupled load. The results capture various electro-mechanical couplings with the formulation proposed for EAP composites [1, 2, 3, 4, 5].

References

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